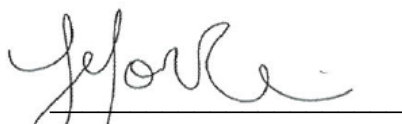


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I, Jacqueline Yorke, hereby certify that the document “**D1 -- JP_H06217239_A**” is, to the best of my knowledge and belief, a true and accurate translation from Japanese into English.

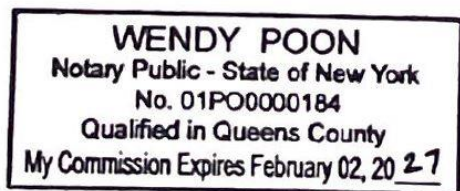


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Signature, Notary Public



Stamp, Notary Public

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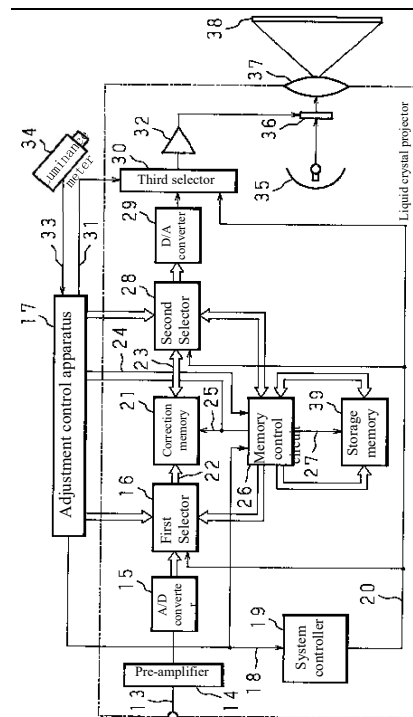
(21) Application number	Japanese Patent Application H5-021736	(71) Applicant	000001889 Sanyo Electric Co., Ltd.
(22) Date of application	January 15, 1993	(72) Inventor	Takaya Nonomura c/o Sanyo Electric Co., Ltd., 2-18 Keihan-hondori, Moriguchi-shi, Osaka-fu
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(54) (TITLE OF THE INVENTION) Liquid crystal projector having a gamma correction function

(57) (ABSTRACT)

(PURPOSE) The aim is to provide a liquid crystal projector having a gamma correction function that will perform gamma correction according to the correction data based on the results of the measurement of the applied voltage - transmittance characteristics in the state in which an LCD panel has been mounted, making it possible to perform correction while the operator actually views the image.

(CONSTITUTION) The liquid crystal projector is provided with luminance meter 34 to measure the luminance of an image, adjustment control apparatus 17 to generate correction data for gamma correction according to the applied voltage - transmittance characteristics of liquid crystal display panel 36 that may be obtained from these measurement results or as a result of a manual operation, correction memory 21 to store the correction data, non-volatile storage memory 39, and first, second, and third selectors 16, 28, and 30 to display video signal input 13 on liquid crystal display panel 36 in the first mode, to write the correction data to correction memory 21 in the second mode, and to enable to mutual transfer of data between correction memory 21 and storage memory 39 in the third mode.



(SCOPE OF PATENT CLAIMS)

(CLAIM 1) A liquid crystal projector having a gamma correction function that is characterized by the fact that it is provided with a liquid crystal display panel to display a video signal as an image;

a projection means to project the image that has been displayed on said liquid crystal display panel onto a screen;

an A/D conversion means to convert the video signal to be displayed on said liquid crystal display panel to digital data;

a correction data storage means to input the digital data that may be obtained as a result of said A/D conversion means as an address signal and to output the data corresponding to the address signal that had been inputted within the gamma correction data that has been stored in advance according to the applied voltage - transmittance characteristics;

and a D/A conversion means to convert the data that may be outputted from said correction data storage means to an analog signal for output it to said liquid crystal display panel; wherein there is

a DC signal generating means to provide a DC signal that may change at a predetermined voltage interval to said liquid crystal display panel as a video signal;

a luminance measuring means to measure the luminance of the image displayed on said liquid crystal display panel or the image projected on said screen;

a characteristics detection means to detect the applied voltage - transmittance characteristics of said liquid crystal display panel according to the measurement results from said luminance measurement means when said DC signal has been provided to said liquid crystal display panel from said DC signal generating means;

a correction data generation means to generate the correction data for gamma correction according to the applied voltage - transmittance characteristics that were detected by said characteristics detection means or as a result of a manual operation;

a non-volatile storage means to store the storage content that may be transferred from said correction data storage means or to transfer its own storage content to said correction data storage means for storage as necessary; a first selector to input the out of said A/D conversion means into said correction data storage means as an address signal in the first mode to display the video signal on said liquid crystal display panel, to input the output of said correction data generation means into said correction data storage means as an address signal in the second mode to adjust the gamma correction, and to connect said correction data storage means and said non-volatile storage means in the third mode to perform the transfer of the correction data between said correction data storage means and said non-volatile storage means;

a second selector to output the data that may be outputted from said correction data storage means to said D/A converter in said first mode, to input the correction data that was generated by said correction data generation means into said correction data storage means in said second mode, and to connect said correction data storage means and said non-volatile storage means in said third mode; and a third selector to cause the input of the signal that may be outputted from said DC signal generation means into said liquid crystal display panel in said first mode and to cause the input of the DC signal that may be

outputted from said DC signal generation means into said liquid crystal display panel in said second mode.

(DETAILED DESCRIPTION OF THE INVENTION)

(0001)

(FIELD OF INDUSTRIAL APPLICATION) The present invention relates to a liquid crystal projector, and more specifically, it relates to a liquid crystal projector having a gamma correction function.

(0002)

(PRIOR ART) A liquid crystal projector is a device that project the images displayed on a liquid crystal display panel onto a screen via a projection lamp, and it may be used for the purpose of meeting the needs of consumers in recent years who wish to enjoy programs on a television screen on a large screen at relatively low cost without using expensive, large, and heavy cathode ray tubes, or for the purpose of projecting video in a comparatively small cinema called a mini-theater, etc.

(0003) However, because the characteristics of the transmittance of projected light relative to the applied voltage of a liquid crystal display panel (hereinafter referred to as the LCD panel) that may be used in a liquid crystal projector (hereinafter referred to as the applied voltage - transmittance characteristics) have a narrow range of linear characteristics, there may be instances in which it demonstrates strong non-linear characteristics on the black or white side during the actual input of the video signal and projection of the image. Therefore, there is a possibility that the liquid crystal projector will project an image that lacks contrast without sufficient black or white gradation.

(0004) In order to avoid the lack of gradation that may occur when displaying video signals in this type of LCD panel, and in order to obtain good gradation and contrast, non-linear processing, which is generally referred to as gamma correction, may be performed. When treating this gamma correction characteristic as $G(v)$, treating the characteristic function of the applied voltage - transmittance as $D(v)$, and the voltage of the input video signal as v , the following formula may be used to represent the transfer characteristic.

(0005) $D(v) \cdot G(v) = k \cdot v$

Here, k is a constant.

(0006) In reality, it is difficult to achieve the ideal correction as described in the above-noted equation, and it is often approximated using several polygonal line circuits. Figure 2 is a block diagram illustrating an example of this type of gamma correction circuit using the conventional analog method. In Figure 2, reference numeral 1 represents the video signal input, 2 is the pre-amplifier, 3 to 5 are the first to third video amplifiers, 6 is the synthetic circuit, and 7 is the LCD panel, respectively.

(0007) Video signal input 1 is inputted into pre-amplifier 2 and is amplified to the appropriate level, after which it is inputted into video amplifiers 3 to 5. These video amplifiers 3 to 5 have different operating regions, and the appropriate gains are set for each operating region. The video signals that have been amplified in each video amplifier 3 to 5 are then regenerated as signals having polygonal line characteristics in synthetic circuit 6 and are amplified to the appropriate level for input into LCD panel 7.

(0008) However, in the case of this type of conventional analog method circuit, for example, in the example shown in Figure 2, video amplifiers 3 to 5 are each set to be responsible for the

black side region, the white side region, and the intermediate region in between, but in order to obtain more detailed characteristics, it is necessary to prepare more video amplifiers, so the circuit size will be increased, and it will also be necessary to adjust the gain due to variability in the parts, which will require significant effort.

(0009) In light of this situation, the digital gamma correction circuit as shown in the block diagram of Figure 3 may also be used today. In Figure 3, reference numeral 8 represents the video signal input, 9 is the A/D converter, 10 is the gamma ROM in which the conversion data is stored based on the transmission characteristics shown in the equation, 11 is the D/A converter, and 12 is the LCD panel, respectively.

(0010) Video signal input 8 is converted to a digital value by A/D converter 9 and is outputted as the address of gamma ROM 10. Gamma ROM 10 uses the digital value that was inputted as the address, and outputs the data that was stored in advance in correspondence to this address. Therefore, the output from gamma ROM 10 becomes a digital value that was transformed using certain rules according to the conversion data based on the transmission characteristics indicated in said equation. Because the digital value output from gamma ROM 10 is returned to an analog signal by D/A converter 11, video signal input 8 will undergo gamma correction as a result, and will be provided to LCD panel 12.

(0011) According to the conventional gamma correction circuit of this digital method, fine characteristics can be obtained by increasing the resolution of the A/D converter and the D/A converter, and by increasing the capacity of gamma ROM 10, so no adjustment will be required. Therefore, the problems in the analog method as described above may be solved.

(0012)

(PROBLEM TO BE SOLVED BY THE INVENTION) However, because the applied voltage - transmittance characteristics of LCD panels are actually dependent on the birefringence of the liquid crystal or the thickness of the liquid crystal layer, etc., the number of high-definition LCD panels such as those used in projectors for high-definition televisions with 1 million pixels or more that can be obtained in a single manufacturing process is small, and therefore, there is increased variability in the quality of individual LCD panels. For this reason, there is the possibility that a circuit with the conversion data fixed as shown in Figure 3 will not be able to deal with this. (0013) Also, this applied voltage - transmittance characteristic is dependent on the wavelength of the projection light source, and in liquid crystal projectors that are constructed of a lamp light source or reflector corresponding to a large LCD panel, and even in the case of a three-color LCD panel, there is variability in the size of the dichroic mirror that separates and synthesizes colors, so it is believed to be better to perform gamma correction according to the individual characteristics in the state in which the LCD panel has actually been mounted.

(0014) The present invention was created in light of these types of circumstances, and the aim is to provide a liquid crystal projector having a gamma correction function that will perform gamma correction according to the correction data based on the results of the measurement of the applied voltage - transmittance characteristics in the state in which an LCD panel has been mounted, making it possible to perform correction while the operator actually views the image.

(0015)

(MEANS FOR SOLVING THE PROBLEM) The present invention is a liquid crystal projector having a gamma correction function that is characterized by the fact that it is provided with a liquid crystal display panel to display a video signal as an image; a projection means to project the image that has been displayed on said liquid crystal display panel onto a screen; an A/D conversion means to convert the video signal to be displayed on said liquid crystal display panel to digital data; a correction data storage means to input the digital data that may be obtained as a result of said A/D conversion means as an address signal and to output the data corresponding to the address signal that had been inputted within the gamma correction data that has been stored in advance according to the applied voltage - transmittance characteristics; and a D/A conversion means to convert the data that may be outputted from said correction data storage means to an analog signal for output it to said liquid crystal display panel; wherein there is a DC signal generating means to provide a DC signal that may change at a predetermined voltage interval to said liquid crystal display panel as a video signal; a luminance measuring means to measure the luminance of the image displayed on said liquid crystal display panel or the image projected on said screen; a characteristics detection means to detect the applied voltage - transmittance characteristics of said liquid crystal display panel according to the measurement results from said luminance measurement means when said DC signal has been provided to said liquid crystal display panel from said DC signal generating means; a correction data generation means to generate the correction data for gamma correction according to the applied voltage - transmittance characteristics that were detected by said characteristics detection means or as a result of a manual operation; a non-volatile storage means to store the storage content that may be transferred from said correction data storage means or to transfer its own storage content to said correction data storage means for storage as necessary; a first selector to input the out of said A/D conversion means into said correction data storage means as an address signal in the first mode to display the video signal on said liquid crystal display panel, to input the output of said correction data generation means into said correction data storage means as an address signal in the second mode to adjust the gamma correction, and to connect said correction data storage means an said non-volatile storage means in the third mode to perform the transfer of the correction data between said correction data storage means and said non-volatile storage means; a second selector to output the data that may be outputted from said correction data storage means to said D/A converter in said first mode, to input the correction data that was generated by said correction data generation means into said correction data storage means in said second mode, and to connect said correction data storage means and said non-volatile storage means in said third mode; and a third selector to cause the input of the signal that may be outputted from said DC signal generation means into said liquid crystal display panel in said first mode and to cause the input of the DC signal that may be outputted from said DC signal generation means into said liquid crystal display panel in said second mode.

(0016)

(OPERATION) In the liquid crystal projector having a gamma

correction function according to the present invention, in the second mode, the gamma correction data that was automatically calculated according to the measurement results by the luminance measurement means, or the correction data that was set by the operator through manual adjustment as necessary, will be written to the correction data storage means, and then in the first mode, the video signal that was inputted in the same manner as in a normal liquid crystal projector will be displayed on the liquid crystal display panel, but in the second mode, gamma correction will be performed according to the correction data that was written to the correction data storage means. Also, in the third mode, the data that has been stored in the correction data storage means will be transferred to and stored in the non-volatile storage means, and conversely, the correction data that has been stored in the non-volatile storage means will be transferred to and written to the correction data storage means.

(0017)

(EXAMPLES OF EMBODIMENT) The present invention will be described in detail below based on the drawings.

(0018) Figure 1 is a block diagram showing the configuration of the liquid crystal projector having a gamma correction function according to the present invention. Although the liquid crystal projector, which normally consists of a three-color LCD panel, has the same circuit for each of the three primary colors, Figure 1 shows only one of the three circuits in total.

(0019) In addition, in Figure 1, the range enclosed by the dashed line is a basic circuit that may be used for a liquid crystal projector, and adjustment control apparatus 17 and luminance meter 34 have been added to this circuit. Furthermore, in Figure 1, the solid lines show the control signals or analog video signals, while the double lines show the digital data.

(0020) In Figure 1, reference code 13 represents the video signal input, and this signal is inputted into pre-amplifier 14 for amplification to the appropriate level. The output of pre-amplifier 14 is inputted into A/D converter 15 and is converted to a digital value for input into correction memory 21 via first selector 16 as address signal 22. The output of correction memory 21 is inputted into D/A converter 29 via second selector 28 as data signal 23 and is converted to an analog signal. The analog signal output from D/A converter 29 is provided to buffer 32 via third selector 30 and is further inputted into LCD panel 36 for display as an image. The image displayed on LCD panel 36 is projected by light source 35 and enlarged by projection lens 37 for projection onto screen 38.

(0021) First selector 16 may select not only A/D converter 15 as described above, but it may also select the output of adjustment control apparatus 17 or of memory control circuit 26, which will be described below, for input as address signal 22 into correction memory 21. In addition, second selector 28 will not only output the digital signal output from correction memory 21 as described above to D/A converter 29 as data signal 23, but will also select either the operation of inputting the digital data that may be outputted from adjustment control apparatus 17 or memory control circuit 26 into correction memory 21 as data signal 23.

(0022) Furthermore, third selector 30 will select either an analog video signal from D/A converter 29 as described above or DC level voltage signal 31 that may be outputted from adjustment control apparatus 17 for output to buffer 32. The selection of the operation each of these selectors 16, 28, and 30

will be controlled by mode switching signal 20 that may be outputted from system controller 19 for provision to each selector.

(0023) System controller 19 will control each selector 16, 28, and 30 as described above, and this control will be performed according to system control signal 18 that may be provided by adjustment control apparatus 17. Adjustment control apparatus 17 may be constructed, for example, of a personal computer, and it may be connected to luminance meter 34. This luminance meter 34 measures the luminance of the image on screen 38 and inputs measurement data 33 to adjustment control apparatus 17. (0024) From adjustment control apparatus 17, system control signal 18 will be outputted to system controller 19 and memory control circuit 26, first memory control signal 25 will be outputted to correction memory 21, store signal 24 will be outputted to memory control circuit 26, and DC level voltage signal 31 will be outputted to third selector 30, while the digital data that will be discussed latter will be outputted to each of first selector 16 and second selector 28.

(0025) Correction memory will use first memory control signal 25 that may be provided from adjustment control apparatus 17 or memory control circuit 26 and address signal 22 that may be inputted via first selector into adjustment control apparatus 17 or memory control circuit 26 to execute an operation to store data signal 23 that was inputted via second selector 28 into adjustment control apparatus 17 or memory control circuit 26, or to execute an operation to output the conversion data that has been stored according to address signal 22 that was inputted via first selector 16 from A/D converter 15 as data signal 23. In addition, memory control circuit 26 is also able to exchange data with non-volatile storage memory 39, and by providing second memory control signal 27 from memory control circuit 26 to storage memory 39, the data can be written to storage memory 39, or conversely, the data stored in storage memory 39 can be read.

(0026) The operation of the liquid crystal projector having a gamma correction function according to the present invention may be performed as follows. First, the characteristics of LCD panel 36 will be measured. More specifically, DC level voltage signal 31 will be outputted from adjustment control apparatus 17 to third selector 30, and at the same time, system control signal 18 will be outputted to system controller 19 to provide instructions for a change in mode switching signal 20. As a result, third selector 30 will select DC level voltage signal 31 according to mode switching signal 20 that may be provided by system controller 19, and will output it to LCD panel 36 as a video signal via buffer 32.

(0027) Adjustment control apparatus 17 will then causes the luminance of the screen that may be projected onto screen 38 at each voltage to be measured by luminance meter 34 while changing the voltage of DC level voltage signal 31 in a predetermined procedure, and will receive measurement data 33 obtained as a result. Further, adjustment control apparatus 17 will multiply measurement data 33 that had been received by a gamma count that is specific to LCD panel 36 in order to determine the applied voltage - transmittance characteristics of LCD panel 36. Third selector 30 will operate to output the output from D/A converter 29 as described below to LCD panel 36 as a video signal via buffer 32 by means of mode switching signal 20 as described above at times other than after the

measurement of the characteristics of LCD panel 36.

(0028) The actual adjustment will be performed as follows. Adjustment control apparatus 17 will prepare the correction data for the output data in relation to the input data to ensure that the video signal will undergo gamma correction corresponding to measurement data 33 that had been obtained from luminance meter 34, and will output the input data to first selector 16, outputting the correction data to second selector 28. For example, if the A/D conversion value of video signal input 13 is n, and the correction is to be performed such that it is converted to m, the data of the value m may be written to address n of correction memory 21.

(0029) In addition, during this adjustment operation, both first selector 16 and second selector 28 will be controlled in order to connect correction memory 21 and adjustment control apparatus 17 by means of mode switching signal 20 that may be provided by system controller 19. First selector 16 will then input the signal of the input data that was outputted from adjustment control apparatus 17 into correction memory 21 as address signal 22, and second selector 28 will input the signal of the correction data that was outputted from adjustment control apparatus 17 into correction memory 21 as data signal 23. These address signals 22 and data signals 23 will be written to correction memory 21 according to first memory control signal 25 that may be outputted from adjustment control apparatus 17 to correction memory 21.

(0030) When the writing of the correction data corresponding to each address to correction memory 21 has been completed in this manner, adjustment control apparatus 17 will perform control to output system control signal 18 to instruct system controller 19 to change mode switching signal 20, to ensure that first selector 16 will input the digital value that may be outputted from A/D converter 15 into correction memory 21 as address signal 22, and to ensure that second selector 28 will input data signal 23 that may be outputted from memory 21 into D/A converter 29.

(0031) After video signal input 13 has been amplified to the appropriate level by pre-amplifier 14, it will be converted to a digital value by A/D converter 15 for input into correction memory 21 as address signal 22 via first selector 16. As a result of this type of operation, video signal input 13 will be converted according to the correction data that was written to correction memory 21, after which it will be returned to an analog signal by D/A converter 29 for input into LCD panel 36 via buffer 32 to show the image. The image displayed on LCD panel 36 will then be enlarged via projection lens 37 by the projection light from light source 35 for projection onto screen 38.

(0032) If the operator thinks that it is necessary to amend the correction state by looking at, for example, the image that has been projected on screen 38 or an image of LCD panel 36 as observed by a waveform measuring device such as an oscilloscope, adjustment control apparatus 17 may be operated in order to amend the correction data, which will then be written to correction memory 21 in the same procedure as described above. Further, if the above-noted steps are repeated until operator believes that there is no need for further correction, it will be possible to achieve accurate gamma correction.

(0033) When the data adjustment work has been completed, adjustment control apparatus 17 will output system control signal 18 indicating the completion of adjustment, and will instruct system controller 19 to change mode switching signal 20. As a result, first selector 16 will operate such that the address signal that may be outputted from memory control circuit 26 will be inputted as address signal 22 of correction memory 21, while second selector 28 will operate such that data signal 23 that may be outputted from correction memory 21 will be inputted into memory control circuit 26, respectively. Also, store signal 24 will be outputted from adjustment control apparatus 17 to memory control circuit 26. As a result of the provision of this store signal 24, memory control circuit 26 will provide the address signal to correction memory 21 to read the correction data, and at the same time, will provide the address signal and second memory control signal 27 to storage memory 39 to write the correction data to storage memory 39. As a result, the final correction data that has been stored in correction memory 21 will be transferred to and stored in storage memory 39.

(0034) Storage memory 39 uses a non-volatile memory, and the correction data will be retained in storage memory 39 even if the power supply of the entire liquid crystal projector has been interrupted. Further, when the liquid crystal projector is powered up again, system controller 19 will first output mode switching signal 20, and second selector 28 will operate such that the address signal from memory control circuit 26 will be inputted as address signal 22 of correction memory 21, and the data signal from memory control circuit 26 will be inputted as data signal 23 of correction memory 21. Next, memory control circuit 26 will output the address signal to correction memory 21 via first selector 16 as well as to storage memory 39, and will provide first memory control signal 25 to correction memory 21 and second memory control signal 27 to storage memory 39. As a result, the correction data that has been stored in storage memory 39 will be read out from storage memory 39 according to the address for transfer to correction memory 21 via second selector 28, and the data will be written to correction memory 21 according to the address.

(0035) When this transfer operation has ended, memory control circuit 26 will provide system control signal 18 to system controller 19 indicating that the transfer has ended. As a result, system controller 19 will output mode switching signal 20, and therefore, first selector 16 will receive the input of the address signal from A/D converter 15 as address signal 22 of correction memory 21, and second selector 28 will operate to output data signal 23 that may be outputted from correction memory 21 to D/A converter 29. As a result, video signal input 13 will be converted and outputted according to the correction data that has been stored in correction memory 21, after which it will be returned to an analog video signal by D/A converter 29 for input into LCD panel 36. This input will be enlarged by projection lens 37 in response to the light emitted from light source 35, and the image that has undergone the proper gamma correction will be projected onto screen 38.

(0036) Thereinafter, the above-noted operation will be repeated each time the liquid crystal projector is powered up.

(0037) In the above-noted example of embodiment, non-volatile storage memory 39 in the liquid crystal projector is used as the means for storing the final correction data after the data adjustment has been completed, but the correction data may be retained in adjustment control apparatus 17, and after the adjustment work has been completed, the correction data may be transferred to an external memory, written to a non-volatile memory. In this way, the non-volatile memory may be replaced with storage memory 39 for mounting into the device, in which case storage memory 39 and memory control circuit 26 may be omitted.

(0038)

(EFFECT OF THE INVENTION) According to the present invention, as detailed above, finer corrections may be made when compared to analog methods, and even if there is manufacturing variability in the LCD panels, it will be possible to not only create correction data according to the characteristics in the mounting state, but also to make corrections while actually checking the correction state on the screen, making it possible to achieve more accurate gamma correction.

(BRIEF DESCRIPTION OF THE DRAWINGS)

(FIGURE 1) This is a block diagram showing the configuration of the liquid crystal projector with a gamma correction function according to the present invention.

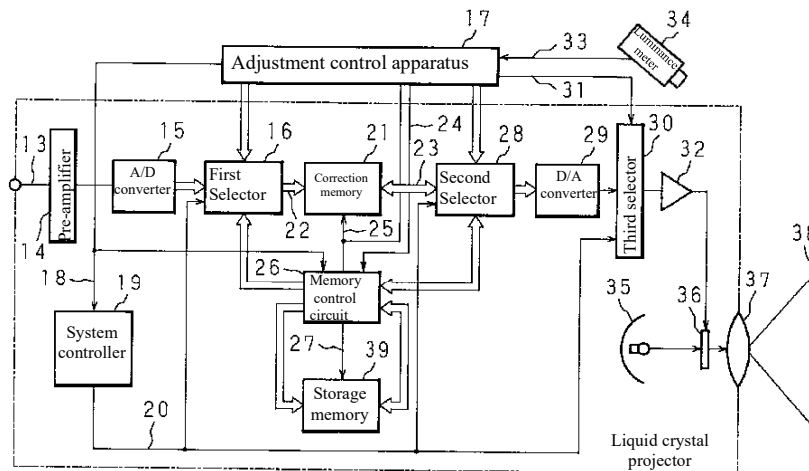
(FIGURE 2) This is a block diagram showing an example of a gamma correction circuit using a conventional analog method.

(FIGURE 3) This is a block diagram showing an example of a gamma correction circuit using a conventional digital method.

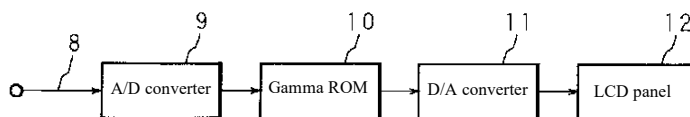
(EXPLANATION OF REFERENCES)

- | | |
|----|------------------------------|
| 13 | Video signal input |
| 15 | A/D converter |
| 16 | First selector |
| 17 | Adjustment control apparatus |
| 19 | System controller |
| 21 | Correction memory |
| 22 | Address signal |
| 23 | Data signal |
| 28 | Second selector |
| 29 | D/A converter |
| 30 | Third selector |
| 34 | Luminance meter |
| 36 | LCD panel |
| 38 | Screen |

(FIGURE 1)



(FIGURE 3)



(FIGURE 2)

